Quantifying nanoscale electromechanical response with the AFM

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The wide variety of electromechanical effects introduced earlier all depend on a sharp tip at the end of a flexible cantilever to localize the physical interactions. The tip radius can easily be less than 100 nm in diameter, allowing routine structural and functional measurements well below the diffraction limit of optical microscopes and competitive with high resolution electron microscopy techniques. This tip does not exist in isolation. It is connected to flexible cantilever which is in turn connected to the mechanical structure of the AFM itself. These connections are all required to use the cantilever in a practical microscope – to control the tip-sample distance and to raster the tip over the surface for example.

In this tutorial, we will dig into understanding the pitfalls and opportunities in quantifying the strain induced the electric field from a biased tip. A good understanding of these pitfalls and how to account for them in your measurements are critical for avoiding false results. Examples include:

- Cantilever dynamics – frequency dependence, instrumental sensitivity and long-range electrostatically driven motion;
- Tip-sample contact mechanics;
- Instrumental effects including crosstalk and noise floors – along with simple methods for characterizing the level of crosstalk in your AFM. I will include a couple case studies from different AFMs.

Finally, I will survey some current challenges and opportunities in electromechanical imaging, especially in the small-electromechanical response limit.